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The Effects of Weather Anomalies on the Quantitative and Qualitative Parameters of Maize Hybrids of Different Genetic Traits in Hungary

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***Abstract*—**Hybrid selection and the application of hybrid specific production technologies are important in terms of the increase of the yield and crop safety of maize. The main explanation for this is climate change, since weather extremes are going on and seem to accelerate in Hungary too.

The biological bases, the selection of appropriate hybrids will be of greater importance in the future. The issue of the adaptability of hybrids will be considerably appreciated. Its good agronomical traits and stress bearing against climatic factors and agrotechnical elements (e.g. different types of herbicides) will be important. There have been examples of 3-4 consecutive droughty years in the past decades, e.g. 1992-1993-1994 or 2009-2011-2012, which made the results of crop production critical. Irrigation cannot be the solution for the problem since currently only the 2% of the arable land is irrigated. Temperatures exceeding the multi-year average are characteristic mainly to the July and August in Hungary, which significantly increase the soil surface evaporation, thus further enhance water shortage. In terms of the yield and crop safety of maize, the weather of these two months is crucial, since the extreme high temperature in July decreases the viability of the pollen and the pistil of maize, decreases the extent of fertilization and makes grain-filling tardy. Consequently, yield and crop safety decrease.

***Keywords*—**Abiotic factors, drought, nutrition content, yield.

I. Introduction

MAIZE is one of the most important cultural plants all over the world, which is capable of the highest productions among cereals constantly. Although we possess state-of-the-art biological bases – as a consequence of the ever frequent weather anomalies caused by climatic changes –, we utilize only approximately 40% of the genetic yield potential. However, the decreased yield stability observed during the past decades and the related unfavorable weather effects can be reduced by harmonic NPK nutrient supply, i.e. the increase of the level of the agrotechnique.

After all, the value of a produced variety is greatly determined by its agro-ecological and production technological adaptabilities, and crop safety [1]. When the ecological and agrotechnical conditions are optimal, the amount of yield is determined by the differences between the hybrids; but in the case of unfavorable weather conditions or shortcomings in the agrotechnique, the most important factor is the adaptability of the hybrids [2]. Nowadays, drought can be expected in 5-6 years out of 10, and as a result, yield fluctuation increased to 30-50% to the 1990s from the 10-20% of the 1980s. Therefore, the hybrid selection in accordance with the ecological conditions and the ensuring of the appropriate crop rotation adjusted to the hybrid specific technology, the harmonic nutrient replenishment, the rationalization of the sowing time and the selection of optimal tiller number harmonizing with ecological, biological and agrotechnical factors are essential [3]. Among the factors influencing crop production, the meteorological factors are characterized with the highest variability. Therefore, the climatic factors make the most pronounced effect on crop production. In Hungary, the monthly average temperatures are higher than those of the lines of latitude during the whole years, but the precipitation amounts are always lower than those of the averages of lines of latitude, except of 1-2 months, and the large precipitation anomalies in the summer and autumn months are also characteristic [4]. The high weather fluctuations can obscure the effects of other agrotechnical factors. In my opinion, the weather can not only obscure but can enhance the effects of the individual agrotechnical factors (the higher-than-average yield depression in the case of monoculture production or the greater-than-expected yields in fertilizer treatments) [5]. Excessive yields could be produced during warm-moist and cool-moist summers, while low yields are developed during warm-dry and cool-dry summers. The risk of maize production is mainly connected with the precipitation shortages [6]. The thermal factors (temperature, duration of sunshine) make greater effects on the duration of an individual phenophase than the hydric ones (precipitation). Comparing the phenophases, the period of startup-tasseling was determined by the meteorological conditions to the less, while the period of tasseling-ripening to the greatest extent, the correlation indices were above those of the period of sowing-start up a bit [7]. With the comparison of the morphological-physiological traits responsible for the yield differences of ancient and modern maize hybrids, one can conclude that the hybrids had the higher LAI and LAD values, growth rates of cob and grain, kernel number and size (sink capacity). The redistribution of assimilates stored in the stalk was higher in the case of hybrids and they had longer grain-filling periods too [8].

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II. Materials and Methods

The experiment was set on the experimental area of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen, using 24 hybrids of different vegetation times (Table I), on lime-coated chernozem soil.

The sub-groundwater is located at the depth of 7-9m. The thickness of the humus layer is 50-70cm. The organic material content of the soil is 2.57%. Due to the lack of lime, the upper layer is dry, thus it is susceptible to crackling in dry cropyears. The year 2012 was an extremely unfavorable cropyear, which is the proof of the ever-problematic climate change. Drought began in July, when only two-third of the precipitation amount of the multi-year average fell. The meteorological data of the vegetation period are listed in Table II.

TABLE I
Classification of the Observed Hybrids by Growing Period

1. P8400	FAO 280	**13. P9494**	FAO 390
2. X9H560	FAO310	**14. P9721**	FAO 390
3. PR38A79	FAO 310	**15. X9N655**	FAO 410
4. P9578	FAO 320	**16. PR37F73**	FAO 410
5. P9175	FAO 330	**17. P9915**	FAO 410
6. P9569	FAO 350	**18. X9N350**	FAO 440
7. X9H960	FAO 350	**19. PR36V52**	FAO 450
8. X9H050	FAO 360	**20. P0195**	FAO 470
9. P9662	FAO 360	**21. PR36V74**	FAO 480
10. PR37N01	FAO 380	**22. P0216**	FAO 500
11. PR37Y12	FAO 380	**23. PR35F38**	FAO 510
12. P9528	FAO 380	**24. X9N952**	FAO 530

TABLE II
The Weather OD Debrecen-Hungary, IN 2012

	Months								
	I.	***II.***	***III.***	***IV.***	***V.***	***VI.***	***VII.***	***VIII.***	***IX.***
Temperature	-0.6 °C	-5.7 °C	6.3 °C	11.7 °C	16.4 °C	20.9 °C	23.9 °C	22.5 °C	18.46 °C
30 years average temperature	-2.6 °C	0.2 °C	5.0 °C	10.7 °C	15.8 °C	18.7 °C	20.3 °C	19.6 °C	15.8 °C
Wet	24.5 mm	19.4 mm	1.8 mm	34.4 mm	56.9 mm	79.3 mm	43.9 mm	7.52 mm	1.07 mm
30 year average wet	37.0 mm	30.2 mm	33.5 mm	42.4 mm	58.8 mm	79.5 mm	65.7 mm	60.7 mm	38.0 mm

Conversely, the mean monthly temperature was 3-4°C higher than the 30-year average. Therefore, the summer months decreased the prospective maize yield. The number of hot days was also above the average, which, in conjunction with the atmospheric drought, caused severe problems in the yield since it took place during the most sensitive phenophase to high temperature and lack of water (male and female flowering; fertilization-grain filling).

The experiment was set after maize preceding crop in two replications, with the application of uniform nutrient dose, divided for autumn and spring (N 160kg ha^{-1}, P_2O_5 80kg ha^{-1}, K_2O 110kg ha^{-1} active substance). Sowing took place on 12-13 April 2012 with two different tiller number settings, the FAO 200-300s: 72 thousand/ha, the FAO 400-500s: 65 thousand/ha. The applied agrotechnical actions were in accordance with the farm practice. We have applied chemical weed control: Laudis at the dose of 2.2 l ha^{-1} and for soil disinfection Force 1.5 G at 12 kg ha^{-1}. The stock was irrigated two times at early July and August by the application of 10mm water each. Harvest was performed at 12th September 2012. The results were evaluated by variance analysis, while the studies on the nutritional values were performed by Infratec 1229 grain analyzer.

III. Results and Discussion

Fig. 1 depicts the yield averages of hybrids in the average of replications, altogether with the grain wet content at harvest.

During the first half of the vegetation period (April to June), the studied stock showed favorable development, the hybrids grew high stalks, but for the time of flowering, fertilization and grain-filling, a considerable water shortage had to be expected. Despite these, out of the 24 hybrids, 17 produced yields above 11t ha^{-1}. The studied hybrids form genetic bases of good adaptability, stress bearing ability and productivity.

The lowest yield was performed by the hybrid P8400 by 10.33t ha^{-1}. The highest yield was produced by the hybrid X9H050 by 11.87t ha^{-1} yield maximum. Approximately 10 t ha^{-1} yield averages were measured in the case of 7 hybrids, while 17 hybrids produced that of above 11 tons. These results are undoubtedly due to the excellent biological bases.

In 2012, as a consequence of the higher-than-the multi-year average temperature, during ripening, the water release accelerated. The water release of hybrids was measured between 14th August and 5th September weekly, at the same time points. The pace of the water release of grains was the most intense between 23 and 30 August. The wet contents of the grains were released the fastest in the case of the hybrids of FAO 300 vegetation times (PR37Y12, P9494).

The grain wet content at harvest was above 15% in the case of only three hybrids (X9N952 18.7%, PR36V74 18.9% and P0216 19%), and even wet content below 10% was experienced in five hybrids (P8400 8.5%; P9578 8.7%; X9H560 9.7%; PR38A79 9.7% and P9569 9.9%).

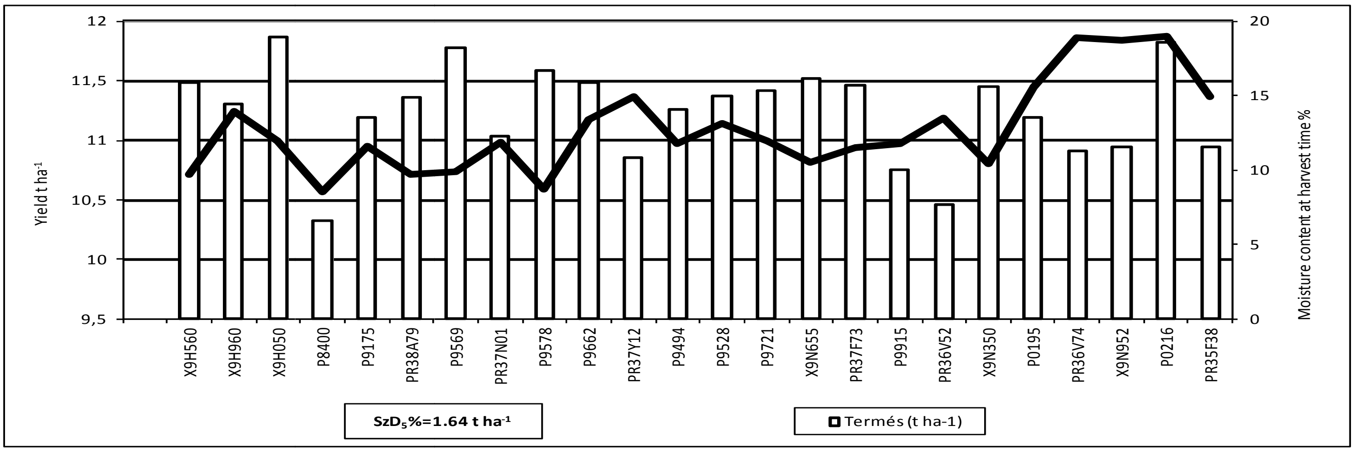

Fig. 1 The yield and moisture content of the examined maize hybrids

During the investigation of the protein content, considerable differences were found among the hybrids (Fig. 2). The values varied between 7.73% (P9528, FAO 380) and 10.41% (PR35F38, FAO 510). The protein contents of four hybrids were below 8%: P9528 (7.73%), P9494 (7.85%), X9H560 (7.9%) and P9578 (7.99%). The average protein content of the hybrids was 8.6%.

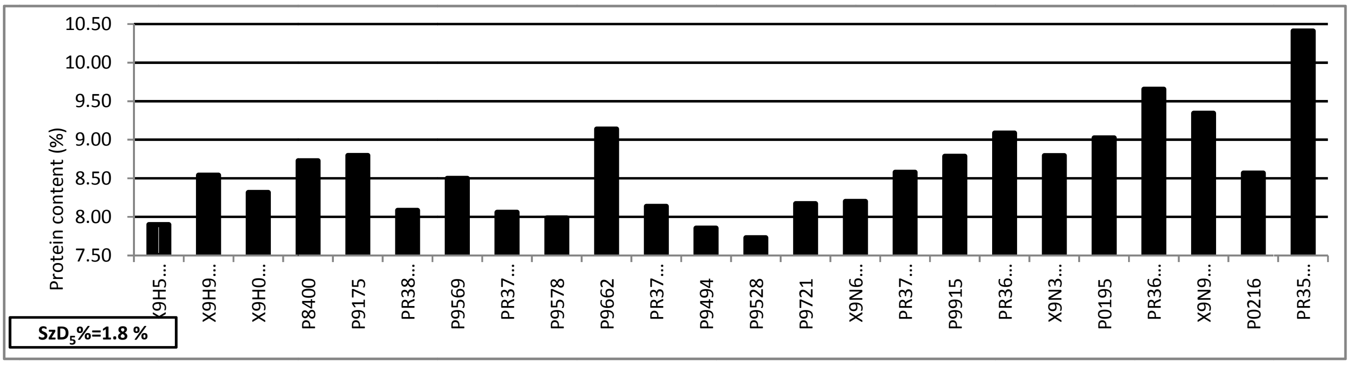

Fig. 2 The protein content of the examined maize hybrids

Evaluating the oil content data of the studied maize hybrids, we have concluded that there were no significant differences between the hybrids (Fig. 3). The values varied between 2.68% (P9915, FAO 410) and 3.82% (X9H050, FAO 360). The average oil content of the hybrids was 3.24%.

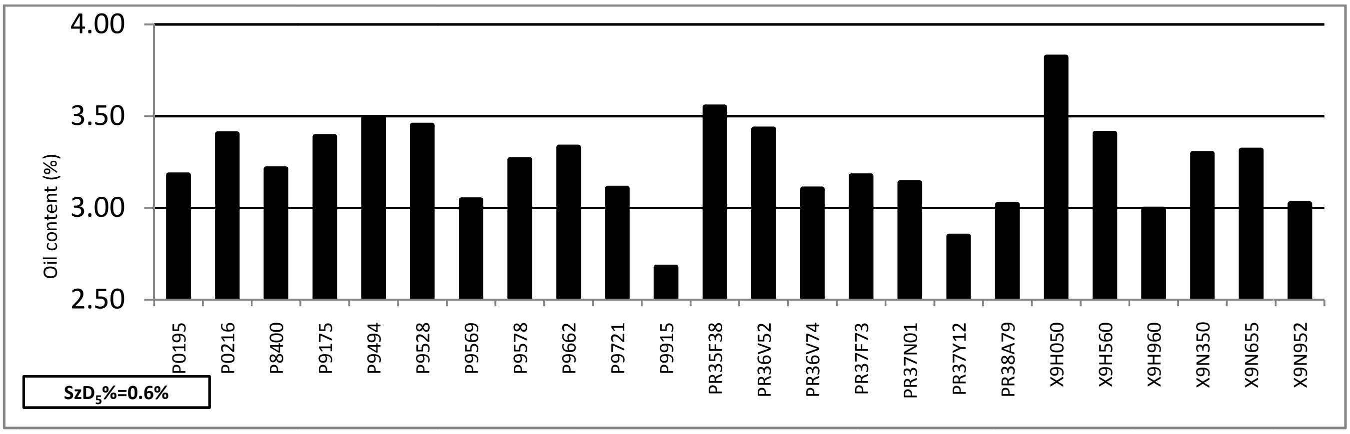

Fig. 3 The oil content of the examined maize hybrids

The differences between the starch contents of the hybrids were significant only in the case of only a few hybrids (Fig. 4).

The starch content values varied between 71.62% (PR35F38, FAO 510) and 73.87% (PR38A79, FAO 310). These results can be considered as very good comparing to the standard values of 65-70% starch content. The average starch content of the hybrids was 72.97%.

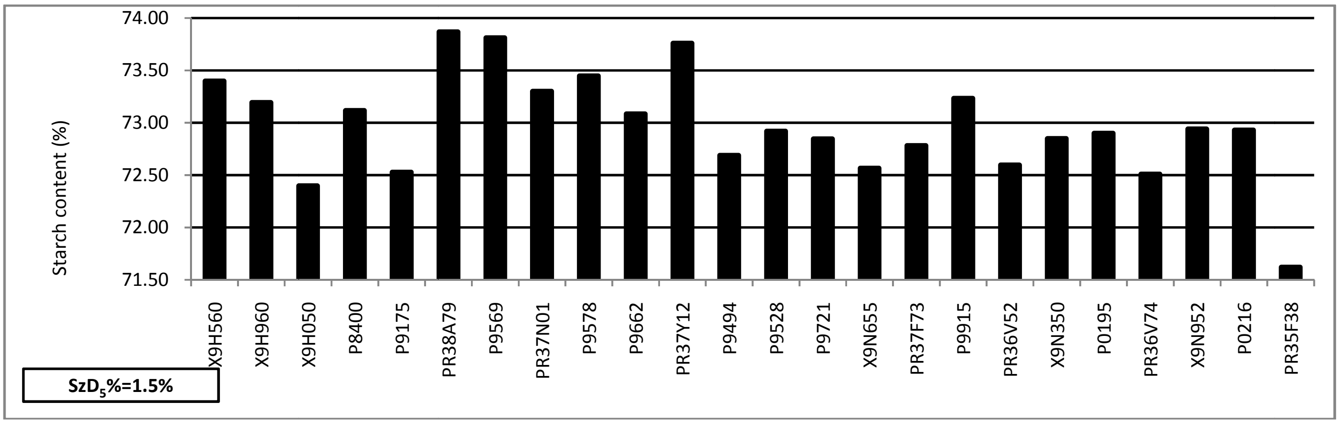

Fig. 4 The starch content of the examined maize hybrid

IV. Conclusion

According to the obtained results, we can conclude that among the production factors (ecological-biological and agrotechnical factors), the ecological factors and the biological bases were rather decisive. Considerable interactions can be observed between these factors.

Despite that the year 2012 was a very droughty cropyear; the studied 24 hybrids produced record yields.

The nutritional parameters are genetically determined traits; however, the environmental factors can influence and modify them. In the future, the conscious hybrid selection and the application of hybrid specific maize production technology will be of great importance.

References

[1] Cs. L. Marton, T. Szundy, G. Hadi, J. Pintér “Practical results of the selection to improve the adaptability of maize (Published work style)”, In.: Adaptability and crop safety of maize hybrids, Debrecen, 2005, pp. 139-146.

[2] Gardner, F.P. -Raul V. - McCloud, D.E. “Yield characteristics of ancient races of maize compared to a modern hybrid”. (Journals style)Agronomy Journal, 1990, 82. 864-868.p.

[3] Liang B. C. - Mackenzie A. F. - K P. C. - Remillard M, “Corn production in relation to water inputs and heat units”. In: Agronomy Journal. 83., 1991, 794-799. p.

[4] M. Jolánkai, Z. Menyhért, E. Széll “Variety value in crop production (Published work style)”, In.: Crop production and environmental protection, Budapest, 1999, pp. 30-36.

[5] M. Sárvári ”The effects of production factors on the yield of maize hybrids (Unpublished work style-thesis)”, unpublished.

[6] Szász G. “Results of the agro-meteorological studies on natural water utilization. Crop production”. (Journals style)Budapest, 1998, Tom. 47. No. 3. 289-300. p.

[7] Varga-Haszonits Z. - Varga Z. “The effects of meteorological factors on the duration of maize phenophases”. (Journals style)Crop production. Budapest, 1998, Tom. 47. No. 5. 503-512. p.

[8] Varga-Haszontits Z. - MikénéHegedűs F. “Meteorological variability and crop production”. (Journals style)Crop production. Budapest. , 1993, Tom. 42. No. 4. 361-373. p.